PLANING PROCESS OF MALAYSIAN TIMBERS II. MECHANICAL EVALUATION OF HIGH SPEED STEEL (HSS) KNIFE EDGE WEAR IN PLANING SOME MALAYSIAN TIMBERS

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ROSLAN ALI, KOMATSU, M. & SAID AHMAD. 1991. Planing process of Malaysian timbers II. Mechanical evaluation of High Speed Steel (HSS) knife edge wear in planing some Malaysian timbers. Wearing characteristics of the high speed steel (HSS) knife in planing keruing, kapur and rubberwood were studied by measuring the profile of the wear at the knife edge and by measuring any increases in spindle motor power at various planing length intervals. Keruing gave the highest rate of wear followed by kapur and rubberwood. The results also show that increase in spindle motor power followed the wear pattern of the knife edge.

Key words: High speed steel knife - edge wear - keruing - kapur - rubberwood - cutting power

Introduction

The frequency of tool change during the wood machining operation depends on the rate of wear of the cutting edge. The more frequent the tool is changed during the period of machining, the more costly it is to machine the timber since tools, grinding wheels and grinding workmanship cost money. One of the factors which influence the rate of wear of cutting edge is the species of timber being machined (Harris 1946). This is because different species have different physical characteristics like density, grain structures and inclusion of abrasive and corrosive substances.

In order to know the effect of various timber species on the blunting of cutting tool used in machining operations, the wear characteristics of the cutting edge have to be evaluated. There are several established methods of evaluating tool wear. The weighing method was used by Eugene (1960) to determine the loss in weight of a tool after it had been subjected to wear , while Meyer and Wu (1967) applied the optical contour mapping technique to measure the tool wear. In a more sophisticated technique, Merchant and Krabacher (1951) used the radioactive tracer which is capable of rapid measurement of tool wear. All the three methods mentioned are carried out for metal cutting research. But in wood cutting research, most of the wear evaluation techniques are made by observing the wear profile of the cutting edge under magnifying instruments such as the tool maker microscope or the electron microscope (Hayashi *et al.* 1986, Inoue 1988).

In this study the wear characteristics of high speed steel knife of dimension 7 × 40 × 600 *mm* used for planing keruing (*Dipterocarpus* sp.), kapur (*Dryobalanops aromatica*) and rubberwood (*Hevea brasiliensis*) were evaluated using a technique which was earlier developed by Fukui and Yokochi (1973). The technique is known as replica mould technique, where a knife edge subjected to wear is moulded using lead fragments and the knife edge profile transferred onto the moulds which are then observed under the magnifying instruments.

Materials and methods

Air dried specimens of kapur, keruing and rubberwood were used as test materials. Their thickness ranged from 37.5 to 50 *mm* while their width and length were 70 and 1000 *mm* respectively. The experiments were carried out on a TAIHEI B11-H 600 *mm* single surface planer. The planer had a 120 *mm* diameter cutter head with three knives rotating at 6000 rpm.

The material composition of the high speed steel knife was as follows: Cr 35%, W 12%, C 2.5%, and Fe 3%. Prior to the start of each cutting test, the back of the knife edge was carefully ground using a carborandum wheel. The front and the back of the knife were then finely honed with oil stone to remove any grinding knicks. During cutting only this knife made the cut since the other two knives were set below the cutting circle. The position of the knife edge was marked. Its initial profile was duplicated by moulding it with a special metal alloy. The replica of the profile obtained from the mould was later analysed under the profile projector.

Timber specimens were then continuously fed into the planer. The feeding direction of timber specimens is coincided with its fibre and longitudinal directions. At various intervals, the length of cut, knife edge wear and spindle motor power consumption were measured. Measurements of knife edge wear were made using the procedure as mentioned earlier while spindle motor power consumptions were measured using a portable power meter complete with digital recorder.

Three sets of tests were carried out as follows:

	Timber species	Knife sharpness angle (°)	Cutting angle (°)	Width of knife mark (*mm*)	Depth of cut (*mm*)
Test 1	Kapur	60*	15	1.3	1.0
Test 2	Keruing	60*	15	1.3	1.0
Test 3	Rubberwood	45	15	1.3	1.0

Note: * The initial knife sharpness angle was 45°, it is modified to 60° by bevelling its front at 15° and with width I 1.5 *mm*

Results and discussion

The profiles of knife edge wear at various planing lengths of keruing, kapur and rubberwood as traced with the aid of the profile projector are as shown in Figure 1. It can be seen that the rate of wear of the cutting edge in cutting rubberwood is many times less than that in cutting kapur and keruing. The knife sharpness angle for cutting rubberwood was purposely made smaller than those for cutting kapur and keruing, but its rate of wear was far less than those for the two latter timbers although a study showed that the smaller the sharpness angle the greater was the rate of wear (Anonymous 1956). This observation confirms the fact that the density of timber influences the rate of wear of knife edge. The average density of rubberwood was 640 $kg\ m^{-3}$ while the densities of kapur and keruing were 760 and 880 $kg\ m^{-3}$ respectively. The rate of knife edge wear in cutting keruing was much greater than that for kapur because keruing is more resinous (Desch 1941).

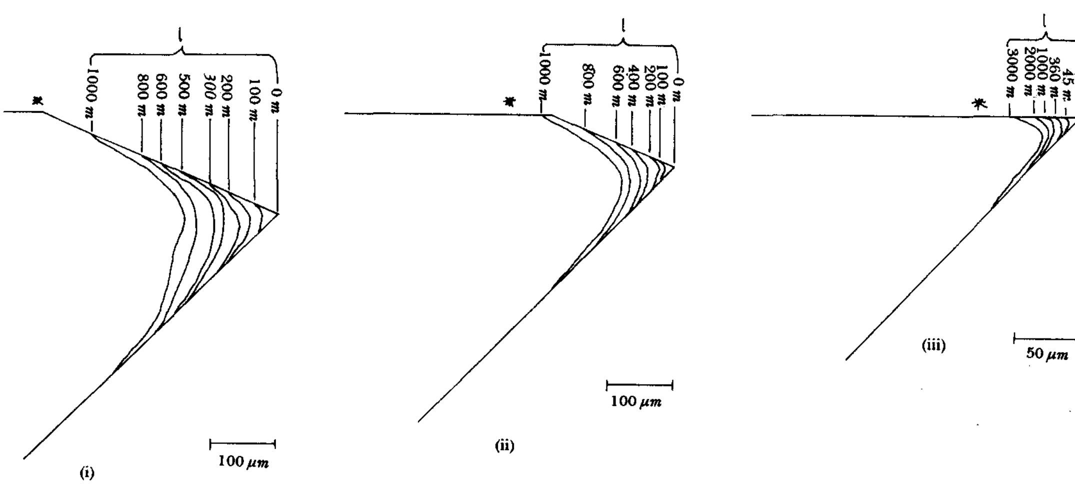

Figure 1. Profile of knife edge wear at various cutting length of (i) keruing, (ii) kapur, (iii) rubberwood (* cutting face; L = planing length)

The clearance face wear (Wc), and cutting face wear (Wf), are defined as in Figure 2. Figure 3 shows the amount of Wc and Wf at increasing planing length of keruing and kapur. While Figure 4 shows the amount of Wc and Wf at increasing planing length of rubberwood.

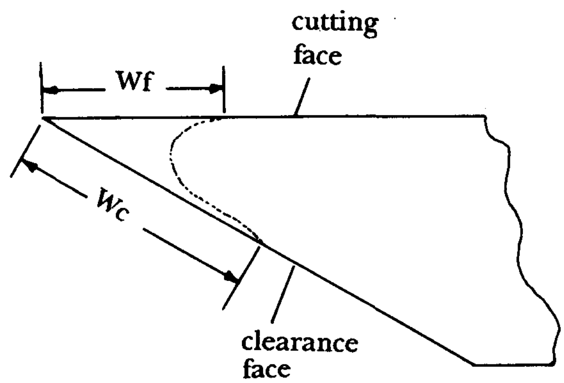

Figure 2. Measurement of clearance face wear, Wc and cutting face wear, Wf of a planer knife edge

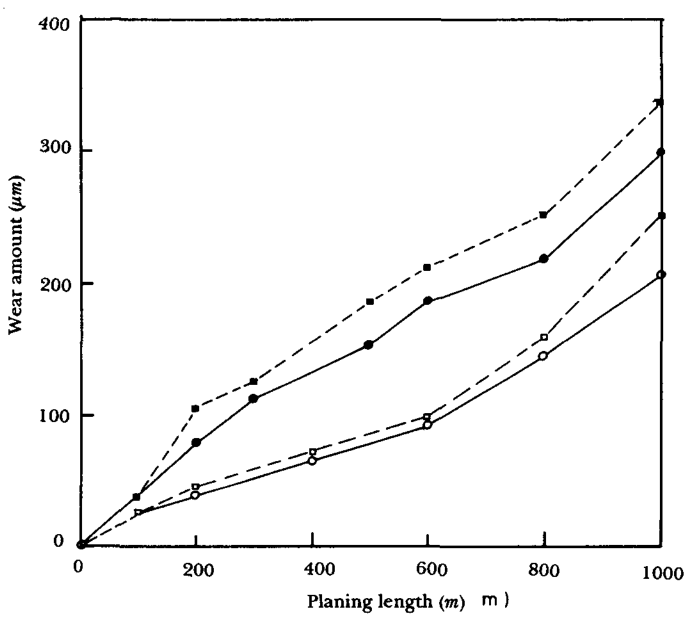

Figure 3. The amount of clearance face wear, Wc and cutting face wear, Wf of the knives at increasing planing length of keruing and kapur (■: Wc - keruing, ● :Wf - keruing, □ : Wc - kapur, ○ : Wf - kapur)

All the figures show that both clearance and cutting face wear increased with the increasing planing length. They also show that the effect of all the three species on the wear pattern was almost the same, that is rapid, gradual and followed by rapid increase in wear, although the effect of kapur and keruing was not so obvious due to their shorter planing length as compared to rubberwood. The ratio of clearance face wear (Wc) to cutting face wear (Wf) at various planing lengths of kapur and keruing is shown in Table 1.

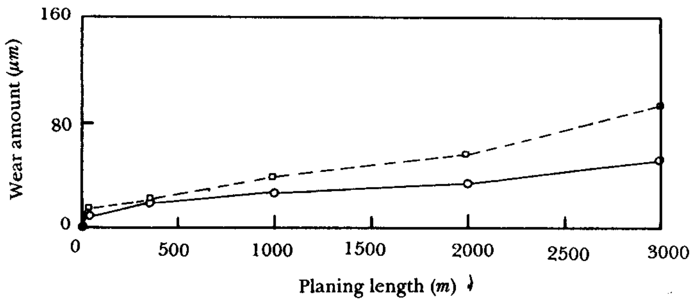

Figure 4. The amount of clearance face wear, Wc and cutting face wear, Wf of the knife at increasing planing length of rubberwood (□: Wc, ○: Wf)

Table 1. Ratio of clearance face wear over cutting face wear (Wc/Wf) at various planing lengths of keruing and kapur

Test specimens	Planing lengths (*m*)							
	100	200	300	400	500	600	800	1000
Keruing	1.2	1.3	1.2	-	1.2	1.1	1.2	1.1
Kapur	1.0	1.2	-	1.1	-	1.1	1.1	1.2

The ratio for rubberwood is shown in Table 2. Both tables show that the ratios Wc/Wf are greater or equal to 1.0. This indicates the typical wear characteristic of tool used in wood machining as observed by Tanaka *et al.* (1986).

Table 2. Ratio of clearance face wear over cutting face wear (Wc/Wf) at various planing lengths of rubberwood

Planing length (*m*)	45	360	1000	2000	3000
Wc/Wf	1.3	1.2	1.5	1.7	1.8

There was a direct relation between the wear of knife edge and the cutting power of spindle motor. The pattern of the increase in cutting power of the spindle motor against the planing length followed the wear pattern of the respective knife edges. Figure 5 shows the pattern of increase of average net cutting power of the spindle motor with increasing planing length of keruing.

Figures 6 and 7 show the pattern of increase of average net cutting power of the spindle motor at the increasing planing length of kapur and rubberwood respectively.

This relationship shows that the cutting power can be used as indicator for monitoring the knife edge wear. Several factors influenced the net cutting power of the spindle motor. Among them were the knife sharpness angle, the density of the cut material and the volume of material removed per minute. In this experiment, the net cutting power recorded was very small since the volume of material removed by the knife was small, that is about 5.46×10^{-4}

$m^3\ min^{-1}$. Hence, instead of using kilowatt (*kw*), the net cutting power of the spindle motor was magnified by using $kw\ min^{-1}$ as unit of measurement.

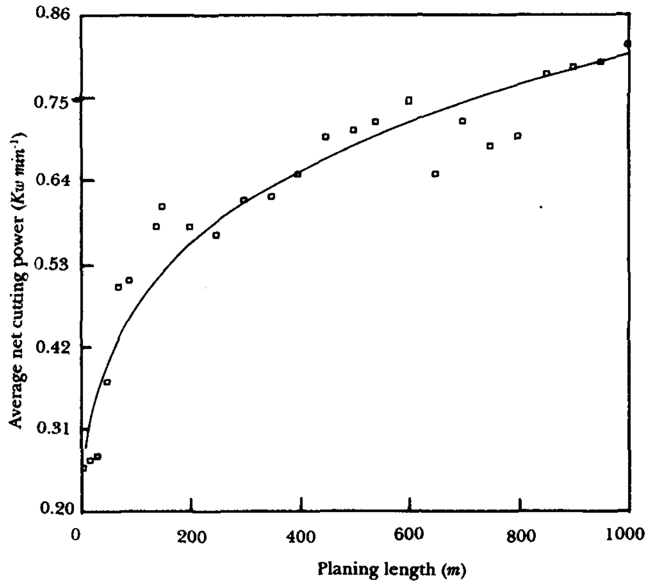

Figure 5. Pattern of increase of average net cutting power of the spindle motor at increasing planing length of keruing

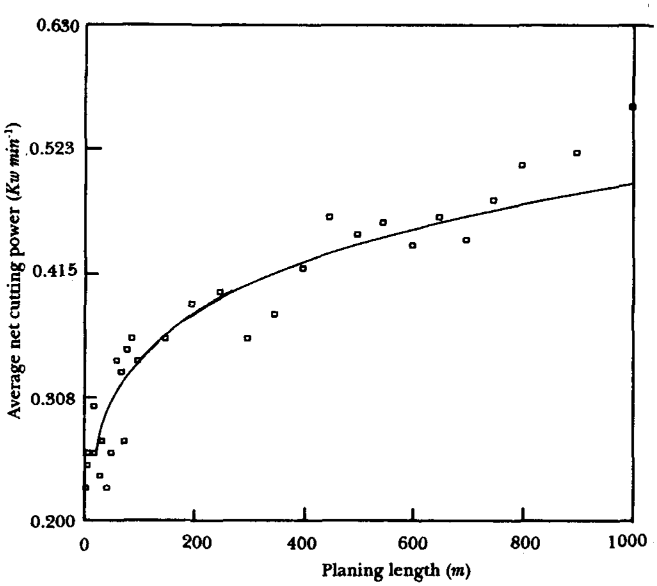

Figure 6. Pattern of increase of average net cutting power of the spindle motor at increasing planing length of kapur

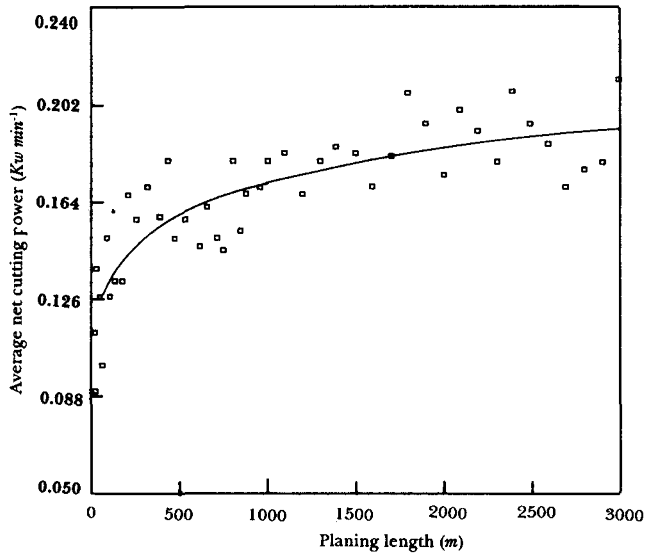

Figure 7. Pattern of increase of average net cutting power of the spindle motor at increasing planing length of rubberwood

Conclusion

The amount of cutting edge wear increased with the increase in planing length. It was also found that the clearance face wore more than the cutting face. Among the three species tested, keruing gave the greatest rate of wear followed by kapur and rubberwood.There was a direct relation between the increase of cutting edge wear and the increase of spindle motor cutting power.

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References

ANONYMOUS. 1956. The blunting of wood cutting edges. *Forest Products Research Special Report No. 11*. Department of Scientific and Industrial Research, London.

DESCH, H.E. 1941. Manual of Malayan Timbers. *Malayan Forest Records No. 15*. Forest Research Institute, Kepong.

EUGENE, F. 1960. *La Coupe des Metaux*. Publication Estoup. Paris.

FUKUI, H & YOKOCHI, H. 1973. The bluntness pattern of milling cutter edges in the machining of wood and wood based materials. *Mokuzai Gakkaishi* 23(3):131-137.

HARRIS, P. 1946. *A Handbook of Wood Cutting*. Forest Products Research. Department of Science and Industrial Research, London.

HAYASHI, K., OONO M. & ITO, M. . 1986. Estimation of tool temperature in the neighbourhood of the cutting edge in peripheral milling of wood. *Mokuzai Gakkaishi* 32(8):603-607.

INOUE, H. 1988. Edge wear of tools tipped with new materials in the cutting of wood. *Mokuzai Gakkaishi* 34(4):291-297.

MERCHANT, M.E. & KRABACHER, E.J. 1951. Radioactive tracers for rapid measurement of cutting tool life. *Journal of Applied Physics* 22(12):1507-8.

MEYER, R.N. & Wu, S.M. 1967. Optical contour mapping of cutting tool wear. *International Journal of Machining Tool Design Research* 7: 128.

TANAKA, C., TAKAHASI, A. & SHIOTA, Y. 1986. Cutting performance of cermet, ceramic, CBN and artificial diamond tools I. Wear from continuous cutting of wood based materials. *Mokuzai Gakkaishi* 32(2):96-102.